Cooperative Learning in the Science Classroom

A new learning model for a new year

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Even though much has been written about cooperative learning in recent years, busy high school teachers contending with heavy curricular and teaching demands might not know much about the instructional method. Equipped with only a partial understanding of cooperative learning, some teachers may view it as a series of forced artificial constructs while others may view it as simply separating students into groups for an activity.

To help high school science teachers make sense of the extensive cooperative learning research over the last two decades, this article summarizes the major ideas behind the cooperative learning teaching model, provides educational research evidence that supports the use of cooperative methods in promoting higher student learning outcomes (Johnson, and Johnson 1994; Johnson, Johnson and Holubec 1998; Joyce, Showers, and Rolheiser-Bennett 1987; Marzano, Gaddy, and Dean 2000; Millis 1995; Slavin 1991; Stahl and VanSickle 1992), and outlines three cooperative learning strategies that can be applied to any science content area (Bianchini, Holthuis, and Nielson, 1995; Bianchini 1997; Bradley et al. 2002; Pratt 2003; Sharma, Millar, and Seth 1999).

Cooperative learning definition

Cooperative learning is an instructional method in which students work in small groups to accomplish a common learning goal under the guidance of a teacher.

The method is characterized by the following features, which are distinct from other forms of group work:

- Learners positively depend on each other in a team to achieve a mutual learning goal.
- Learners engage in face to face interactions.
- Learners are assessed individually and held accountable for equally sharing and contributing to the mastery of learning goals.
- Learners use and develop appropriate collaborative and interpersonal skills to teach and encourage each other to learn.
- Learners reflect and assess the effectiveness of group functioning for future learning (Johnson and Johnson 1999; Kagan 1994).

Cooperative learning processes lessen individual competitiveness and foster cooperative small problem-solving group behavior (Cooper 1990; Johnson, Johnson, and Holubec 1998; Joyce, Showers, and Rolheiser-Bennett 1987; Marzano, Gaddy, and Dean 2000; Millis 1995; Slavin 1991; Stahl and VanSickle 1992). By having learners treat each other as resources and requiring learners to go beyond only superficial engagement with learning materials, cooperative learning provides the social context for students to actively learn and make deeper connections among facts, concepts, and ideas.

Cooperative learning research

Three primary purposes of using cooperative learning are to develop students' social and communication skills, increase tolerance and acceptance of diversity, and improve academic achievement. Researchers found that students who participated in cooperative learning exhibited less competitive behavior and more cross ethnic cooperation than those who participated in whole class teaching (Sharan et al. 1984). Researchers also found that cooperative learning promotes better relationships among students with special needs and varying races and ethnicities (Johnson and Johnson 1999).

In addition, research shows that humans learn best when they collaborate with others and actively process personally meaningful information. Surveying the research on innovative teaching practices that lead to higher student achievement, researchers concluded that the cooperative learning model was ranked first in teaching approaches that promote greater higher order thinking, problem solving, and achievement (Joyce, Showers, and Rolheiser-Bennett 1987). Moreover, Moore's (2005) research showed that after a classroom lecture by the teacher students were only able to retain 5% of the information presented, and after a classroom demonstration by the teacher students were only able to retain 30% of the information, both after 24 hours. In contrast, when students used major components of cooperative learning by practicing their new learning or teaching it to others, or applied their learning immediately, they were able to retain 75% to 90% of the material after 24 hours. This is not to say that teachers should abandon lecturing or demonstrations. Rather, additional strategies must be used to complement various instructional models that will enhance student learning.

Linking cooperative learning to science

Cooperative learning allows teachers to achieve at least three major instructional objectives listed in the National Science Education Standards (NRC 1996):

1. Cooperative learning improves students' thinking and helps them construct their own understanding of science content by strengthening and extending their knowledge of the topic. The sharing of ideas allows students to explore, refine, and question new ideas (Chi et al. 1994; Chin and Brown 2000; Jones and Carter 1998; Wood 1992).
2. Cooperative learning promotes student involvement and engagement. Research often shows that for true learning to occur, students must take responsibility for their own learning and not depend solely on the teacher. The use of cooperative learning supports this outcome and provides all students with public opportunities to make their thoughts visible to others by allowing them to talk about and consider their own as ideas as well as those of others (Chin and Brown 2000; Jones and Carter 1998; Kagan 1994; Wood 1992).
3. Cooperative learning aids in the development of important communication skills and scientific thinking processes. Cooperative techniques provide the social settings in which teachers can help students analyze their thinking processes and encourage all students to interact with their teachers and peers in a way that is conducive to science learning (Chin and Brown 2000; Jones and Carter 1998; Meyer and Woodruff 1997; Millis 1995; Resnick and Klopfer 1989; Wood 1992).

Using cooperative learning

Many varying cooperative learning structures exist that can be integrated into the science classroom. The following sections outline three variations of cooperative learning structures ranging from simple to very complex forms that are applicable for any secondary level science classroom.

Three-minute review tactic with alternative think-pair-share

The review tactic structure involves a three step process in which students are first asked to think and

FIGURE 1

Examples of possible group member roles in formal cooperative groups

Students may be assigned to only one role or a combination of roles during an activity.

Group roles	Task in group
Leader/manager/organizer	Manages the group and ensures that members fulfill their roles in a timely manner.
Recorder	Records group's answers and discussion outcomes.
Materials manager/technician	Collects materials for the group and performs technical information analysis.
Skeptic/questioner	Ensures that all possibilities have been explored by posing questions such as "What's another idea?" or "How can we look at this problem in another way?"
Reflector	Observes and notes the group dynamics for better future group functioning.
Time keeper	Keeps the group on-task and within the time limits for the activity.
Encourager/coach	Ensures that all members are participating.
Reader	Reads the instruction or any information orally to the group.
Reporter/spokesperson	Reports the groups' conclusions to the whole class.
Checker	Checks group members to ensure that each member can explicitly explain how the conclusion/solutions were derived.

summarize the key concepts on a list for one minute. After the minute, pairs of students alternate and share only one key point at a time with each other for two minutes. Alternatively, the two minutes can be divided into one-minute segments. During the first minute, one student talks while the other actively listens, making only supporting comments but not offering his or her own ideas. During the second minute, these roles are reversed. Students add any missing points to their own list. This structure may be used during hypothesis-seeking activities, or when reviewing concepts during lectures or discussions, generating experimental/calculation procedures, or exchanging ideas on controversial issues.

Head count and formal roles

The head count structure promotes both individual and group thinking and reflection on issues, questions, or problem-solving. Each member in a team of four is numbered off as 1, 2, 3, or 4. Each member is assigned a role in the group: Number 1 is the leader/manager (manages the group and ensures that members fulfill their roles and work cooperatively in a timely manner); Number 2 is the recorder (records the group's answers and discussion outcomes); Number 3 is the materials manager/technician (collects materials for the group and performs technical analysis for the group including using calculators, etc.); and Number 4 is the skeptic/reflector (ensures that all possibilities have been explored by posing questions such as "What's another idea?" or "How can we look at this problem in another way?" Also observes the group dynamics). (See Figure 1 for possible alternative group roles.)

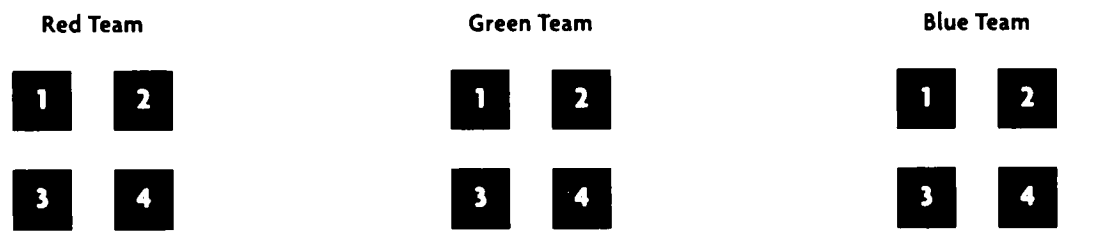
After the roles are assigned, the teacher poses a question. For instance, at the conclusion of an inquiry activity, the teacher may ask: "What were the major ideas that were applied in solving your problem and what is their order of importance in arriving at your conclusions?" Group members individually consider the question and jot down their thoughts. Following this, students exchange their ideas and produce their group response, summary, or consensus, which is then recorded. The teacher can poll the recorders from each group to give the answer. Alternatively, the teacher can call on all the team managers to provide answers. Depending on the lesson objectives, a quiz may be given at the end of the lesson.

One way to implement this structure in the classroom is for a teacher to provide a chemical equation and then ask students to balance the equation on their own and share their thinking with others in the

FIGURE 2

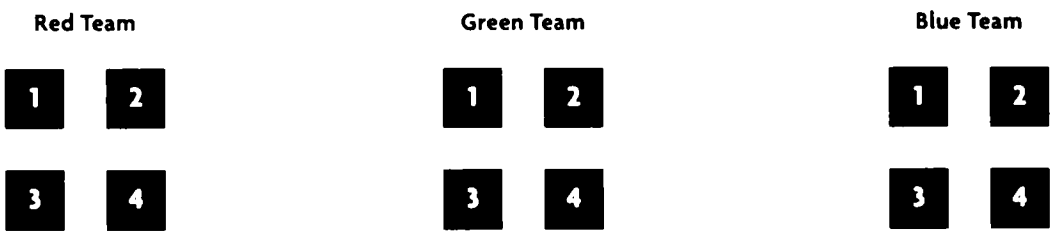
Jigsaw formation.

1. Gather in home groups (three to six members grouped heterogeneously).



2. Gather in expert groups (students reorganize to work with other members to learn about their topic).

3. Return to home groups (students return to their home groups to present what they learned from their expert groups).



4. Assessments.

Students are given group and/or individual quizzes. In addition, the teacher guides students in evaluating how well their groups worked together and assists them to think of ways to improve their cooperative skills for future activities.

group. The group members would take on the group roles, share their thinking, come to a consensus, and then the recorder would display the final group answer. Each member of the group would have to be familiar with how the answer was derived since the teacher could call on anyone to represent the group.

Jigsaw

The jigsaw structure (Aronson and Patnoe 1997) consists of giving an assignment or problem to students to solve and involves four major steps:

1. Students in the class are divided and assigned to heterogeneous study teams called home groups (three to six members each). The academic material is broken down into smaller topics or sections and presented to the students in text form.
2. Each member of the home group is then assigned a different topic/section and is responsible for learning that portion of the assigned material. Students from different home teams but with the same assigned learning portion meet with each

other to discuss and help one another learn the common material, forming expert groups.
3. After learning their portion of the material in their expert groups, students return to their home groups to teach their home team members what they have learned (Figure 2, p. 37).
4. Students are then tested on what they learned. This structure may be used for learning new material, reviewing old material, solving complex problems, or viewing relationships among factors.

This scenario would work well in a biology class, when the teacher's objective is to have students understand the role of antibodies, white blood cells, and histamines in fighting disease. Students would first form home groups using colored index cards: red, green, and blue. In the home groups, each student would be assigned one of three topics and provided an informational sheet about the topic: antibodies, white blood cells, or histamines. Only one student in the home group would be assigned to each topic and would be responsible for being an "expert" on that topic.

All the students would read their assigned topic and meet with other students assigned to the same topic to discuss, clarify, and summarize the main ideas in writing. Textbooks and other reference materials could be provided to each group, and the teacher should circulate among groups to facilitate student comprehension of more difficult concepts. After becoming experts about their topic, students would then return to their home groups and each member would explain the main ideas that they learned in their expert groups. Either individual or group quizzes would be given after sharing information in the home groups.

General considerations

Problem behaviors during group collaboration have been one major concern voiced by some teachers attempting to implement these structures in their classrooms. Often, the teachers fear that some students may adopt behavior that could obstruct the functioning of the group. Also, assessment must be done in a way that is equitable. Some ways to ensure successful group collaboration may include:

- Heterogeneous grouping that would enable lower-achieving students to work with higher-achieving students. Considerations should be given to students' ability, cultural norms, and working and learning styles when considering the makeup of the learning teams. Additionally, learning teams are constituted for short durations and only for the purpose of completing a task and should be disbanded once the task is completed.
- Facilitating the process by encouraging students to acknowledge problems as "group problems" rather than as individual problems. The teacher conducts discussions about expected roles and behavior.
- Modeling or simulating desired language or group behavior.
- Varying assessment depending on the length and purpose of the collaborative task. For relatively short collaborative tasks observer feedback or individual and group processing and reflection would be appropriate (no grades or points need to be given). However, if the purpose is to attain skills and knowledge, typical evaluation methods such as quizzes, tests, group presentations, checklists, and other types of reports may be used. Similarly, a final product in longer collaborative tasks may be appropriate with students being able to demonstrate mastery learning objectives. As well, evaluation of group processing that promotes the understanding of social skill development and encourages tolerance and positive interactions may be gathered at the end of tasks with the use of self- and group-written reflections.
- Rewarding positive interdependence and individual accountability. Both of these reward structures can be gradually increased as students become more skilled at the collaborative process and have an increasing investment in the group's success. For instance, establish a goal for "minimum" group performance. If every member of the group achieves the minimum standard of performance, each member receives a predetermined bonus score. Providing bonus incentives and rewards, rather than group grades, can avoid the perception that group work punishes some students who happen to work with less-motivated peers.
- Allowing students to rate their group members' performances and their own contributions during the discussions.

- Introducing cooperative group tactics gradually by first reading and trying some activities suggested in references listed at the end of this article.

I have used cooperative learning strategies interspersed with other teaching models throughout my science teaching and found that all students – whether English-language learners, learning-disabled students, or accelerated learners – develop into a community of learners that models the process of open information exchange, which characterizes science. Over time, students eagerly voice and debate scientific ideas and come to accept and share responsibility for their own learning. They begin to reflect on their own thinking and are more aware of their own decision-making and problem-solving skills. In the end, students not only develop deeper thinking and listening skills but also become cohesive units working together to meet challenges. ■

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